PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 16462-WO-03	**FOR FURTHER ACTION** See Form PCT/IPEA/416	
International application No. PCT/IL2004/000616	International filing date *(day/month/year)* 08.07.2004	Priority date *(day/month/year)* 09.07.2003
International Patent Classification (IPC) or national classification and IPC G01N15/14		
Applicant P.M.L - PARTICLES MONITORING TECHNOLOGIES LTD.		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 8 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 8 sheets, as follows:
      ☐ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
01.05.2005	24.10.2005
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer Koch, A Telephone No. +31 70 340-3828

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/IL2004/000616

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

   Description, Pages

   1-30 as originally filed

   Claims, Numbers

   1-35 received on 01.05.2005 with letter of 27.04.2005

   Drawings, Sheets

   1/13-13/13 as originally filed

   ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-35
	No:	Claims	
Inventive step (IS)	Yes:	Claims	6,22,26,27
	No:	Claims	1-5,7-21,23-25,28-35
Industrial applicability (IA)	Yes:	Claims	1-35
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 The following document is referred to in this communication:

D1: JONES A R: "Light scattering for particle characterization" PROGRESS IN ENERGY AND COMBUSTION SCIENCE, ELSEVIER SCIENCE PUBLISHERS, AMSTERDAM, NL, vol. 25, no. 1, February 1999 (1999-02), pages 1-53, XP004151620 ISSN: 0360-1285

D2: PIESTUN RAFAEL: "Multidimensional Synthesis of Light Fields" 17 October 2001 (2001-10-17), - 1 November 2001 (2001-11-01) page 28, XP002302678 Retrieved from the Internet: URL:http://ece-www.colorado.edu/~piestun/2 8-32.PIESTUN.PDF> [retrieved on 2004-10-26]

D3: MATIZEN Y E ET AL: "FORMATION OF NON-GAUSSIAN LIGHT BEAMS WITH THE AID OF A SPATIALLY INHOMOGENEOUS AMPLITUDE FILTER" SOVIET JOURNAL OF QUANTUM ELECTRONICS, AMERICAN INSTITUTE OF PHYSICS. WOODBURY, NY, US, vol. 17, no. 7, 13 January 1987 (1987-01-13), - 1 July 1987 (1987-07-01) pages 886-887, XP000709131

D4: FRIEDMANN MICHAEL ET AL: "Surface Analysis Using Multiple Coherent Beams" ELECTRICAL AND ELECTRONICS ENGINEERS IN ISRAEL, 5 November 1996 (1996-11-05), - 6 November 1996 (1996-11-06) pages 537-540, XP002302679

D5: FRIEDMANN MICHAEL ET AL: "Resolution enhancement by extrapolation of the optically measured spectrum of surface profiles" APPLIED OPTICS, vol. 36, no. 8, 10 June 1996 (1996-06-10), - 21 October 1996 (1996-10-21) XP002302680

D6: PIESTUN RAFAEL ET AL: "Pattern generation with an extended focal depth" APPLIED OPTICS, vol. 37, no. 23, 10 August 1998 (1998-08-10), - 20 April 1998 (1998-04-20) pages 5394-5398, XP002302681

2 INDEPENDENT CLAIM 1

2.1 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of amended claim 1 does not involve an inventive step in the sense of Article 33(3) PCT.

2.1.1 The closest prior art is seen in the document D1 disclosing the instrument designed by Kaye et al. and its method of application (the references in parenthesis applying to this document):
A method of particle size and concentration measurement (page 3, column 2, paragraph 5) comprising the following steps:

- providing a focussed laser beam (p. 37, col. 1, par. 2; fig. 25)
- causing said beam to interact with said particles (p. 37, col. 1, par. 2; fig. 25);
- measuring the interaction signal of said beam with said particles (p. 37, col. 1, par. 2; fig. 25) and number of interactions per unit time (p. 37, col. 1, par. 3); and
- using algorithms to map said interaction signals (p. 37, col. 1, par. 2 and 3).

2.1.2 Claim 1 differs from D1 by the following technical features:

(1) the focussed laser beam being a synthesized, non-Gaussian laser beam
(2) mapping the interaction signals to said particle size and said number of interactions per unit time to said concentration
(3) wherein said focused, synthesized, non-Gaussian laser beam is a dark beam.

2.1.3 The following technical problems are related with the technical features (1)-(3) from 2.1.2 of this Report:

(1') investigating the influence of a non-Gaussian beam shape on scattering of laser beams by particles (feature (1))
(2') deriving particle size and concentration from the experimental results (feature (2))
(3') to obtain a narrower dark central spot than the "smeared" Gaussian "doughnut" mode provides and to keep a constant notch while propagating a pre-defined distance.

2.1.4 A non-Gaussian laser beam and the related technical problem (1') are already disclosed in D1 (p. 10, col. 2, par. 3-p. 11, col. 1, par. 3). Thus it is suggested in D1 that the beam shape is important in the scattering process and that it is worth investigating the case of a non-Gaussian beam. The skilled person who would attempt to solve the related technical problem (1') would certainly find document D2 during search, D2 disclosing multidimensional control and synthesis of non-Gaussian light fields, suggesting their application to microscopy as applied in biochemistry, chemistry and materials processing (p. 28, col. 2, l. 4-col. 3, par. 1 and 2). The skilled person would not only find feature (1) and related technical problem (1') in D2, but would also learn that a synthesized non-Gaussian beam provides a much narrower central notch and keeps it constant during propagation over a pre-defined distance. Therefore the skilled person would also find feature (3) and related technical problem (3') disclosed in D2, would recognize the advantages of the synthesized non-Gaussian beam and would incorporate into the well-known method of Kaye described in D1, without an inventive step being involved. There is also no doubt that a dark non-Gaussian beam is disclosed in D2 (fig. 2 (b) and p. 30, col. 2, par. 2).

Moreover, feature (2) and related problem (2') are already well-known from the prior art and are part of the knowledge of the skilled person, as is also suggested in D1 (p. 3, col. 2, par. 5; p. 22, col. 2, par. 2 and p. 37, col. 1, par. 2 and 3: "...attempts have been made to compare the observed patterns with theoretical predictions using the RGD approximation [...]." ff).

3 INDEPENDENT CLAIM 28

3.1 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of amended claim 28 does not involve an inventive step in the sense of Article 33(3) PCT.

3.1.1 Amended independent claim 28 referring to system for particle size and concentration measurement comprises over claim 1:

(a) a scanning mechanism;

(b) means for converting said Gaussian laser beam into said focused synthesized, non-Gaussian laser beam being chosen from the following group:
a combination of a spatial filter and a lens, and
a liquid crystal device.

The remaining features of claim 28 are analogous to the features of method claim 1 and have been considered above; these features do not imply an inventive step (c.f. section 2.1 and subsections of this Report).

3.1.2 The technical problem solved by feature (a) is seen in:
(a') generating a synthesized non-Gaussian laser beam.
The technical problem solved by feature (b) is seen in:
(b') maximising spatio-temporal focussing.

3.1.3 The technical features (a) and (b) and the related technical problems (a') and (b') are known already from the document D2 (p. 31, col. 1, par. 2 and fig. 3a and its figure caption of D2: (a), (a'); p. 31, col. 3, par. 1-p. 32, col. 1, par. 1 and fig. 5 of D2: (b), (b')). The diffractive structure of D2 technically corresponds to the "spatial filter" of the application, the refractive structure and the structured lenses technically correspond to the "lens" of the application.

3.1.4 The skilled person, attempting to solve technical problems (a') and (b') would incorporate the teaching of document D2 regarding these problems into the common set-up of a scattering experiment as the one designed by Kaye et al. which is disclosed in D1 and would arrive at a system according to claim 28, without an inventive step being involved.

4. Dependent claims 2-5,7-21,23-25 and 29-35 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step, see documents D1-D6 and the corresponding passages cited in the search report.
D3-D6 disclose:
D3: the formation of non-Gaussian light beams, e.g. of a circular non-Gaussian light

beam with a central dark spot;

D4: confocal optical scanning of a surface with a focussed non-Gaussian light beam of different shapes, for obtaining a lateral resolution better than 0.3 microns and an axial resolution better than 10 nm;

D5: scanning a surface along a linear path using a focussed Gaussian beam; and

D6: 3D-pattern generation involving a lens and a diffractive element.

5. The subject-matter of the following claims seems to be novel and inventive in the sense of Article 33(1)-(3):
Claims 6, 22, 26 and 27,
since their technical features have neither been anticipated nor suggested in any of the prior art documents.

Claims

1. A method of particle size and concentration measurement comprising the following steps:
   - providing a focused, synthesized, non-Gaussian laser beam:
   - causing said beam to interact with said particles;
   - measuring the interaction signal and number of interactions per unit time of said beam with said particles; and
   - using algorithms to map said interaction signals to said particle size and said number of interactions per unit time to said concentration

   wherein said focused, synthesized, non-Gaussian laser beam is a dark beam.

2. A method according to claim 1, wherein the particles are fluid borne, airborne, or on a surface.

3. A method according to claim 1, wherein the size of the particles ranges from sub-micron to thousands of microns.

4. A method according to claim 1, wherein the measurements are made in the intensity domain.

5. A method according to claim 1, wherein the measurements are made using the mapping of the interaction pulse width to particle size.

6. A method according to claim 1, wherein the focal properties of the laser beam are changed depending on the size and concentration range of the particles.

7. A method according to claim 1, wherein the non-Gaussian beam is generated by employing a mask over a Gaussian laser beam.

8. A method according to claim 8, wherein the Gaussian beam is spatially modulated.

9. A method according to claim 8, wherein the Gaussian beam is spatially modulated by use of spatial-filter, a set of spatial filters, an electronic spatial light modulator, or a liquid crystal device.

10. A method according to claim 8, wherein the spatial modulation of the Gaussian beam is chosen from the group comprising:

- intensity modulation;
- phase modulation;
- wavelength modulation
- polarization, modulation; and
- combinations of these.

11. A method according to claim 11, wherein the spatial modulation is implemented statically.

12. A method according to claim 11, wherein the spatial modulation is implemented dynamically

13. A method according to claim 1, wherein the non-Gaussian beam is generated by directly modifying the laser cavity or combining the beams from several lasers.

14. A method according to claim 1, wherein the interaction of the focused beam with the particles is accomplished by causing said particles to flow relative to a stationary beam.

15. A method according to claim 1, wherein the interaction of the focused beam with the particles is accomplished by providing

a scanning mechanism that provides a linear scanning path for said focused beam.

16. A method according to claim 1, wherein the interaction of the focused beam with the particles is accomplished by providing a scanning mechanism that provides a rotary scanning path for said focus beam.

17. A method according to claim 1, further comprising the use of a detection system to measure radiation scattered at 90 degrees to the beam direction to verify single particle interaction in the focal area or as an additional dark field information.

18. A method according to claim 18, wherein the detection system used to measure radiation scattered at 90 degrees to the beam direction comprises a CCD camera.

19. A method according to claim 18, wherein the detection system used to measure radiation scattered at 90 degrees to the beam direction comprises several detectors.

20. A method according to claim 20, wherein the several detectors are connected in a way selected from the group: addition, differential, and coincidence.

21. A method according to claim 1, wherein a detection system is used to measure radiation back-scattered from the particles.

22. A method according to claim 1, further comprising the use of a detector to measure radiation scattered at 90 degrees to the beam direction to detect smaller particles using dark field TOT measurement.

23. A method according to claim 1, wherein high concentrations of particles are measured by using a reflection, back scatter, mode, collecting the back-scattered interaction energy from the particle.

24. A method according to claim 19, wherein counting interaction signals, of the scanning laser beam, per unit time is used to measure high concentrations of particles.

25. A method according to claim 1, wherein the algorithms to map the interaction signals to the particle size and the

number of interactions per unit time to the concentration are explicitly based on said interaction signals.

26. A method according to claim 1, wherein the algorithms to map the interaction signals to the particle size and the number of interactions per unit time to the concentration are based on an advanced artificial intelligence method.

27. A method according to claim 1, wherein the advanced artificial intelligence method is a Neural Network or support vector method (SVM).

28. A system for particle size and concentration measurement comprising:

- one or more lasers to provide a Gaussian laser beam;
- a scanning mechanism;
- means for converting said Gaussian laser beam into a focused, synthesized, non-Gaussian laser beam; and
- detection means;

wherein said focused, synthesized, non-Gaussian laser beam is a dark beam and said means for converting said Gaussian laser beam into said focused, synthesized, non-Gaussian laser beam are chosen from the following group:

- a combination of a spatial filter and a lens; and
- a liquid crystal device.

29. A system according to claim 29 additionally comprising a second detection system to measure the radiation scattered at 90 degrees to the beam direction.

30. A system according to claim 29, additionally comprising a beam splitter to divert back-scattered interaction energy from the particle to the detection system.

31. A method according to claim 1, wherein the synthesized, non-Gaussian laser beam is circular.

32. A method according to claim 1, wherein the synthesized, non-Gaussian laser beam is linear.

33. A method according to claim 1, wherein the particle size is determined by differential interference of the light scattered from said particle with the two lobes of a linear synthesized, non-Gaussian laser beam.

34. A method according to claim 1, wherein the particle size is determined by analyzing the polarization of the light scattered from said particle.

35. A method according to claim 1, wherein two or more confocal beams are simultaneously generated, each of said beams having a different wavelength.